<Advanced Research Center for Beam Science> Laser Matter Interaction Science

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Max-Born-Institute, Germany, 17 June 2004

Scope of Research

The research subjects are ultra-intense and ultra-short laser-matter interactions and their applications. The physics of nano-ablation and nano-structure formation on the surface of solid with short-pulse lasers are investigated, inquiring the new material science such as laser nano-processing and material creation. The process of ionization of large molecules and tissue with short pulse lasers is also studied to develop new mass spectrometers. With ultra-intense lasers, the physics of high energy radiation generation and its applications are done research into. Ion generations by Coulomb explosion of molecules, clusters, and micro-particles, and sheath acceleration in thin foils and their applications to nuclear science are studied to open a new field of laser nuclear science. In the cooperation with the Laboratory of Electron Microscopy and Crystal Chemistry and the Laboratory of Structural Molecular Biology, the applications of laser produced electrons and x-rays to electron microscopy and x-ray analysis, respectively, will be studied. With the Laboratory of Particle Beam Science, new accelerator physics with laser-produced ions will be developed. For the applications of short pulse lasers to chemistry, biology, material physics, and medical science we will collaborate with laboratories of this institute to challenge to develop a new field of interdisciplinary science. Main facility is the T6-laser (10TW, 100fs) available since 2004.

Research Activities (Year 2004)

Presentations

Ion generation in a low density plastic foam by Coulomb explosion with an intense femtosecond laser", S. Sakabe, M. Hashida, S. Shimizu, T. Iida, F. Sato, S. Okihara, K. Nishihara, T. Zh. Esrkepov, T. Norimatsu, K. Nagai, and Y. Izawa, International Workshop on Fast Ignition and High Field Physics 2004, 25 - 29 April 2004, Kyoto, Japan.

Proton generation from hydrogen cluster Coulomb-exploded by intense femtosecond laser pulses, M. Hashida, S. Sakabe, S. Shimizu, T. Iida, F. Sato, S. Okihara, T. Kagawa, K. Nishihara, K. Imasaki, and Y. Izaw, International Workshop on Fast Ignition and High Field Physics 2004, 25 - 29 April 2004, Kyoto, Japan.

Coulomb-explosion of argon cluster intense femtosecond laser pulses, S. Shimizu, S. Sakabe, M. Hashida, T. Iida, F. Sato, S. Okihara, M. Hirokane, T. Kagawa, and Y. Izawa, International Workshop on Fast Ignition and High Field Physics 2004, 25 - 29 April 2004, Kyoto, Japan.

Possibilities of controllable ablation by femtosecond lasers, A. Kinoshita, M. Fujita, M. Hashida, Y. Izawa, T. Nakayama, M. Katto, and K. Nagashima, LPM2004 20 - 21 May 2004, Nara-ken New public hall, Japan.

X-ray spectroscopic measurements to study energy transport by hot electrons in ultra-intensity laser produced plasma, H. Nishimura, Y. Inubushi, M. Ochiai, S. Fujioka, T. Kawamura, S. Okihara, M. Hashida, S. Simizu, S. Sakabe, S. Kato, F. Koike, S. Nakazaki, T. Matsuoka, R. Kodama, K. A. Tanaka, K. Mima, H. Nagatomo, T. Johzaki, Y. Kitagawa, H. Fujita, T. Jitsuno, N. Miyanaga, T. Norimartsu, K. Nagai, and Y. Izawa, International Symposium on Ultrafast Intense Laser Science 3, September 16 - 20, 2004, Palermo, Sicily.

Grants

Sakabe S, Fundamental Research on γ-ray Laser with Intense Femtosecond Lasers, Grant-in-Aid for Scientific Research (B)(2), 1 April 2003 - 31 March 2005.

Sakabe S, Research on Coulomb Explosion Dynamics of Cluster Molecules with Intense Lasers, Grant-in-Aid for Scientific Research Priority Areas (C), 1 April 2003 - 31 March 2004.

Award

Hashida M, Furukawa H, Tsukamoto M, Fujita M, Izawa Y, 2003 LSJ Award for Distinguished Achievements in research, Femtosecond laser ablation of metals: characterization of new processing region and formation of nanostructures The Laser Society of Japan, 28 May 2004.

Completion of Laser Science Building for High Power Laser Facility in Advanced Research Center for Beam Science

To equip with ultra-intense femtosecond laser system T6-laser, a new laser building was completed adjacent to the building of accelerator facility. The laser building is constructed for less mechanical vibration on the floor against earthquake and high stability of temperature and humidity controls against muggy summer in Kyoto so that the laser system can be operated stably for long time. The building consists of a laser room and a laser-irradiation room. In 2004 fiscal year, the T6-laser system will be installed and be in operation. The part of laser irradiation experiment room will be opened for collaborators of ICR, Kyoto University, and other institutes. The T6-laser is named by the acronym of Table-top Ten TW Ten Hz Tunable Ti:sapphire laser. The system is Ti:sapphire chirped-pulse amplifier laser, delivering 1J (at maximum), 100fs pulses at a center wavelength of 800nm and repetition rate variable from single shot to 10Hz at maximum.

Energy Distributions of Ions Emitted from Argon Clusters Coulomb-exploded by Intense Femtosecond Laser Pulses

Energy distributions of ions emitted from argon clusters (up to 12 800 atoms/ cluster) Coulomb-exploded with an intense femtosecond laser have been experimentally studied. Under the laser intensity of $2x10^{16}$ W/cm^2, the ions of >15 keV are anisotropically emitted, while those lower than 15 keV tend to be isotropic. The argon ions of charge state up to Ar^{14+} were generated, and their high charge state is more than expected by the barrier suppression ionization model. The yield and maximum energy of Ar^{8+}-Ar^{14+} ions depend on laser polarization direction, while those of Ar^{+}-Ar^{7+} are much less sensitive to the laser polarization. The present results suggest that high-charge-state and anisotropically emitted ions are produced by impact ionization of electrons that are produced by optical field ionization with the intense laser.

Periodic Structure of Metals with Femtosecond Laser Nano-Ablation

The laser ablation for Cu, Al, Fe, Zn, Ni, Pb, and Mo by short pulse laser (800 nm wavelength, 100 fs pulse duration, 1 kHz repetition rate) in air was studied. The craters produced by laser ablation were measured with a scanning electron microscope (SEM) and an atomic forced microscope (AFM). A periodic structure was observed at the bottom of the crater in all metals. The periodic structure was always oriented perpendicular to the electric field of laser polarization. A dependence of the periodic structure on the laser fluence was demonstrated in the range of 0.01-2 J/cm^2 for copper. The spacing d of the patterned structure was determined to be d =300±40 nm for 0.07 J/cm^2 and d =600 ±40 nm for 0.22 J/cm^2. As the laser fluence decreased, the spacing of the patterned structure had the tendency to be shorter. The formation of the periodic structure could not be explained by classical interference model. Some possible mechanisms in relation to the process of the periodic structure are discussed.

Desorption/ionization of Poly-aromatic Hydrocarbons with Intense Femtosecond Laser

Desorption/ionization of PAHs irradiated with intense femtosecond laser (800 nm wavelength, 100 fs pulse duration) was studied by-means-of time-of-flight mass spectrometry. The molecular ions without heavy fragmentation was observed at the laser intensity around the ionization threshold. The siganl intensity of the molecular ions increases with increasing the laser intensity. The ionization mechanism was suggested the non-resonant multiphoton ionization. The desorption/ionization with intense femtosecond laser will have a great possiblility as a new soft-ionization method.